

Wetlands Drought Index

This Factsheet provides a detailed technical description of the indicator Wetland Drought Index based on SPI of a series of accumulation periods, produced by the Copernicus Global Drought Observatory (GDO), which is used for detecting and characterising meteorological and hydrological drought. The variable of the hydrological cycle upon which the SPI indicator produced by GDO is based, as well as the indicator’s temporal and spatial scales and geographic coverage, are summarized below. An example of the detailed report of a wetland affected by drought is presented in figure 1.

Variable	Temporal scale	Spatial scale	Coverage
Precipitation	Monthly	Indicative	Global

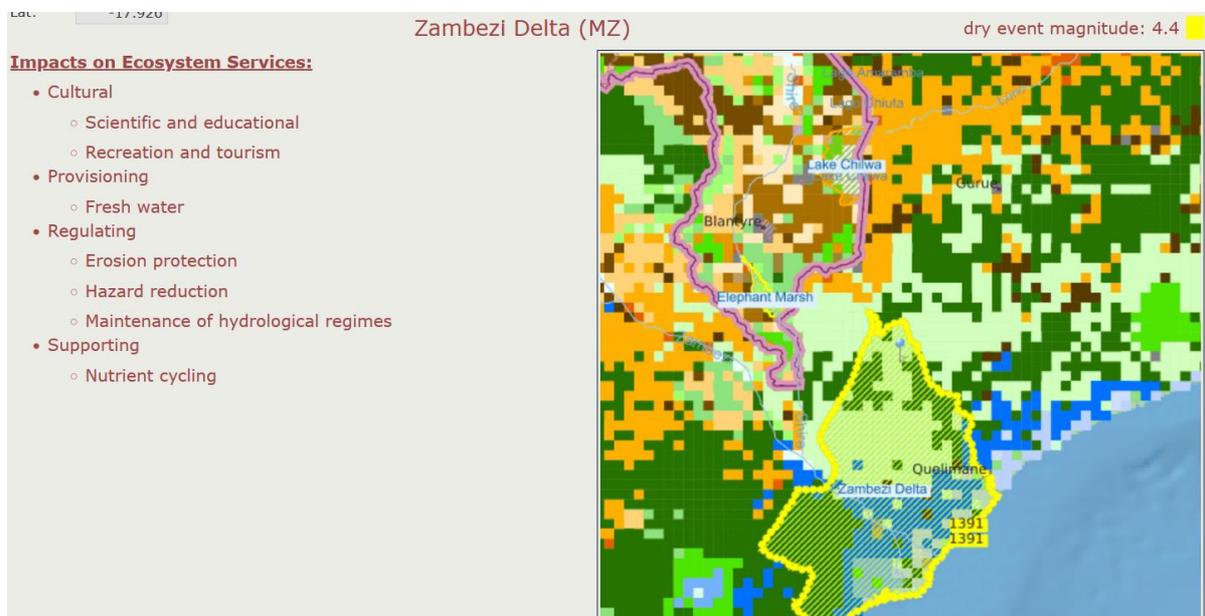


Figure 1: Example of the wetland index based on SPI indicators, produced by the Copernicus Global Drought Observatory (GDO). The wetland concerned is the Zambezi Delta in Mozambique in June 2022, affected by a dry event with magnitude 4.4

1. Brief overview of the indicator

The Standardised Precipitation Index (SPI) is the most commonly used indicator worldwide for detecting and characterising meteorological and hydrological droughts. Hydrological Droughts are relevant for Wetlands since most wetlands are in direct contact with the subsurface water table which lowers during a long term drought identified by a long term SPI value. The SPI indicator, which was developed by McKee et al. (1993), and described in detail by Edwards and McKee (1997), measures precipitation anomalies at a given location, based on a comparison of observed total precipitation amounts for an accumulation period of interest (e.g. 1, 3, 6, 9, 12, 24, 48 months), with the long-term historic rainfall record for that period. The historic record is fitted to a probability distribution (the “gamma” distribution), which is then transformed into a normal distribution such that the mean SPI value for that location and period is zero. For any given region, increasingly severe rainfall deficits (i.e., meteorological moving to hydrological droughts) are indicated as SPI decreases below -1.0 , while increasingly severe excess rainfall are indicated as SPI increases above 1.0 . Because SPI values are in units of standard deviation from the long-term mean, the indicator can be used to compare precipitation anomalies for any geographic location and for any number of time-scales. Note that the name of the indicator is usually modified to include the accumulation period. Thus, SPI-3 and SPI-12, for example, refer to accumulation periods of three and twelve months, respectively. The World Meteorological Organization has recommended that the SPI be used by all National Meteorological and Hydrological Services around the world to characterise droughts uniformly (World Meteorological Organization, 2012). The long-term gamma distribution of our product is based on data from a reference period from 1981 to 2010 (included). The data included in the SPI-48 (4 years SPI) are thus based on monthly rainfall input data from 1978 until 2010.

2. What the indicator shows

A drought is defined as a period with an abnormal precipitation deficit, in relation to the long-term average conditions for a region. The SPI indicator shows the anomalies (deviations from the mean) of the observed total precipitation, for any given location and accumulation period of interest. The magnitude of the departure from the mean is a probabilistic measure of the severity of a wet or dry event. Since SPI can be calculated over different precipitation accumulation periods (typically ranging from 1 to 48 months), the resulting different SPI indicators allow for estimating different potential impacts of a meteorological drought:

- **SPI-1 to SPI-3:** When SPI is computed for shorter accumulation periods (e.g., 1 to 3 months), it can be used as an indicator for immediate impacts such as reduced soil moisture, snowpack, and flow in smaller creeks.
- **SPI-3 to SPI-12** When SPI is computed for medium accumulation periods (e.g., 3 to 12 months), it can be used as an indicator for reduced stream flow and reservoir storage.
- **SPI-12 to SPI-48:** When SPI is computed for longer accumulation periods (e.g., 12 to 48 months), it can be used as an indicator for reduced reservoir and groundwater recharge.

It should be borne in mind that the exact relationship between the accumulation period and the drought impact, depends on the natural environment (e.g., geology, soils, landuse and landcover) and the human interference (e.g., extraction of water). In order to get a full picture of the potential impacts of a drought, the SPI should be calculated and compared for different accumulation periods.

A comparison with other drought indicators is also needed, in order to evaluate the actual impacts on the vegetation cover and different economic sectors.

3. How the indicator is calculated

The indicator is based on a weighting of negative SPI values for the 7 determined accumulation periods (1, 3, 6, 9, 12, 24, 48 months). The weighting value is called a magnitude. When a SPI value is below -2 a score of 1 is attributed to the magnitude. Accumulation periods of 3, 6 and 9 months contribute if below -1 with 0.5 to the magnitude. The maximum magnitude is therefore $7 + 1,5 = 8.5$. If the magnitude is above 4 then the wetland is signaled to be affected by drought. Hence, if more than 3 accumulation periods result in an extreme value the wetland is signaled. The wetlands analysed are all protected areas of the RAMSAR treaty, often a refuge for protected species, both plants and animals. If more than 1 pixel of 1 by 1-decimal degrees intersects the wetland, the most affected pixel will be analysed. A drought might result in an extreme event reducing the number of protected species, especially when the wetland is not connected to other areas allowing the mobile species to move to wetter areas during the drought event. Another reported effect of drought on wetlands is the irreversible change of soil properties in the wetland after a drought event, cracking but also oxidation of peat or iron layers might change the physical properties of the wetland irreversible.

How a wetland reacts to a drought event is difficult to predict and dependent on local particularities. In the analysis report, the land cover and the wetlands main ecosystem functions are reported to assist the user in making an assessment.

4. Strengths and Weaknesses of the Indicator

Strengths:

- The fact that SPI values are in units of standard deviation from the long-term mean, allows SPI to be computed and compared for any geographic location and for any number of time scales.
- By creating a magnitude we can signal if an extreme drought persist across the different time intervals, thus damaging the long term resilience of a wetland to interrupted drought events. Wetlands are especially sensitive to the lowering of the water table of the subsurface water, which might be affected after repeated drought events. Further we can 'tune' the magnitude for specific local conditions, such as a wetland in an area with sandy soils, being more sensitive or a wetland along a large river being less sensitive and more related to the low-flow characteristics of the river.
- The SPI indicator is based on only one input parameter (precipitation accumulations), and thus it is less complex to compute than other drought indicators, such as the Palmer Drought Severity Index, which also takes account of variations in temperature, soil moisture and evapotranspiration.

Weaknesses:

- Wetlands are very specific territories often related to a large groundwater body or a river in the neighbourhood. Such relations might be dominant for the functioning of the wetland with respect to a drought. Using a global observation, without feedback from the field, such particularities are not taken care of. The method can however be adopted by local protection organisations with a fine-tuning on how a particular wetland depends on a series of precipitation deficits.
- The signal is determined by a geographical intersection of the protected area polygon of the wetland with the 1 by 1 decimal degrees grid cells upon which the SPI computation is based. The area that affects the wetland for drought might be different, especially when the wetland is connected to a river or a groundwater body. Low flow caused by hydrological drought upstream might be not detected.
- Because SPI is based only on precipitation, it does not address the effects of high temperatures on drought conditions, such as by damaging cultivated and natural ecosystems, and increasing evapotranspiration and water stress. A new variation of SPI - the Standardized Precipitation and Evapotranspiration Index (SPEI) - has been developed (Vicente-Serrano et al., 2010), which includes precipitation and temperature, in order to identify increases in drought severity linked with higher water demand by evapotranspiration. The SPEI has the advantage over the Palmer Drought Severity Index (PDSI), for example, in that it captures the “multiscalar” characteristic of drought, whereby water deficits accumulate over different time-scales, differentiating between hydrological, environmental, agricultural, and other droughts. Because it includes temperature, the SPEI indicator, which will be added to the European Drought Observatory in the future, is particularly suited to monitoring the effects of global warming on drought conditions.

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